This document is guaranteed to be current only to issue date.

Some Mars Global Surveyor documents that relate to flight operations are under revision to accommodate the recently modified mission plan.

Documents that describe the attributes of the MGS spacecraft are generally up-to-date.

542-424

Mars Global Surveyor

Detailed Mission Requirements

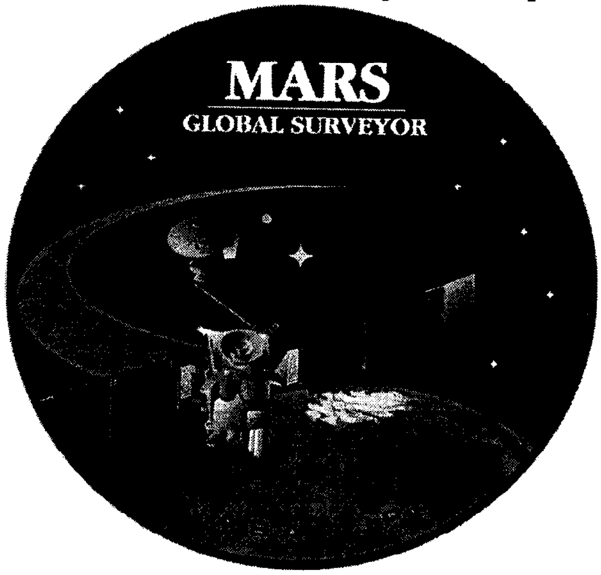
Final

November 1995

Jet Propulsion Laboratory
California Institute of Technology

JPL D-12785

Mars Global Surveyor Project



Detailed Mission Requirements

Final Version (MGS 542-424, November 1995)

Concurred by:

S.S. Dallas
MGS Mission Manager

Concurred by:

M. Traxler
Telecom. & Mission Services Manager for MGS

Approved by:

G. Cunningham
MGS Project Manager

Approved by:

N. Haynes
Telecom. & Mission Operations Director

JPL
Jet Propulsion Laboratory
California Institute of Technology
Pasadena CA, 91109

National Aeronautics and
Space Administration

1. Program Information, Administrative, and Technical

1.1 Introduction

In accordance with NMI 8430.1c, the Mission Requirements Request dated 10 October 1994 from Code S Office of Space Sciences to Code O Office of Space Communications, requests tracking and data acquisition support for Mars Global Surveyor (MGS).

The Letter of Response, from Code O to JPL dated September 1, 1994 designates JPL as the Lead Center for tracking and data acquisition support for MGS, and authorizes the use of NASA facilities to provide the support requested.

This Detailed Mission Requirements (DMR) document establishes detailed mission requirements on the NASA Deep Space Network and NASCOM for that support, and identifies the combined response on an item by item basis.

1.2 Approval Authority

NASA Program Office	Code S Office of Space Sciences
Program Name	Mars Global Surveyor
NASA Program Manager	M. K. Olsen
Project Manager	G. Cunningham
Lead Center for Telecom. & Mission Operations	Jet Propulsion Laboratory
Lead Center Director	E. Stone
Lead Center, Telecom. & Mission Operations Director	N. Haynes
Lead Center, Telecom. & Mission Services Manager	M. Traxler

1.3 Revision Control

Revision Number 0 (Draft)	July 1994
Revision Number 1 (Preliminary)	May 1995
Revision Number 2 (Final)	November 1995

1.4 Abbreviations and Acronyms

The abbreviations used in this document are normally defined after the first textual use of the corresponding term. However for convenience, a list of abbreviations is given below:

AMMOS	Advanced Multi Mission Operations System
AD	Applicable Document
ATDF	Archival Tracking Data File
CCAS	Cape Canaveral Air Station
CDSCC	Canberra Deep Space Communications Complex
DMR	Detailed Mission Requirements
DRVID	Differenced Range Versus Integrated Doppler

DSS	Deep Space Station
EIRP	Effective Isotropic Radiated Power
ETR	Eastern Test Range
HEF	High Efficiency (Antenna)
JPL	Jet Propulsion Laboratory
KSC	Kennedy Space Center
MAG/ER	Magnetometer/ Electron Reflectometer
MGS	Mars Global Surveyor
MGSO	Multi-Mission Ground Systems Office
MO	Mars Observer
MOC	Mars Orbiter Camera
MOI	Mars Orbit Insertion
MOLA	Mars Orbiter Laser Altimeter
MR	Mars Relay
MRR	Mission Requirements Request
ODF	Orbit Data File
PAM	Payload Assist Module
SFDU	Standard Formatted Data Unit
TES	Thermal Emissions Spectrometer
TCM	Trajectory Correction Maneuver
TMOD	Telecom. & Mission Operations Directorate
TMI	Trans-Mars Injection
USO	Ultra Stable Oscillator

1.5 Responsibilities

The organizational responsibilities within the MGS Project are given below:

Program Office NASA	M. K. Olsen
Project Center	Jet Propulsion Laboratory
Director, Project Center	E. Stone
Project Manager	G. Cunningham
Mission System Manager	S. Dallas
Spacecraft System Manager	G. Pace
Mission Operations System Design	S. Linick
Flight Operations Development	J. Schmidling
Ground Data System	F. Hammer
Mission and Navigation Design	J. Beerer
Launch Operations	V. Wirth
Telecom. and Mission Services Manager	M. Traxler
Network Operations Project Engineer	D. Recce

1.6 Applicable Documents (AD)

1) 542-422	MGS Mission Requirements Request
2) 542-400	MGS Mission Requirements Document
3) 542-405	MGS Mission Plan
4) 542-xxx	MGS / DSN Telecommunications Design Control Document

5) 542-409	MGS Mission Operations Specification (vol. 1, 2, 3)
6) DSN 810-5 rev. D	DSN / Flight Project Interface Design Handbook (vol. 1,2)
7) DSN 820-13	DSN System Requirements: Detailed Interface Design
8) DSN 870-333	DSN Network Operations Plan for MGS
9) JPL D-11514	MGS Trajectory Characteristics Document

1.7 Summary of Exceptions to Project Requirements

There exists two possible limitations to the Project requirements listed in this version of the DMR.

Limitations:

a) The 0.1 mm radio metric data requirement by radio science may only be supported at the 0.2 mm per second level when using BWG antennas with 4 kW uplink. Project use of the BWG antenna will only be accepted on a negotiated case by case basis using the resource allocation process.

b) The DSN cannot meet part of the phase noise requirements specified in item “j” of the open loop radio science requirements. The phase noise at 1 Hz offset will be -52 dBc instead of the specified -53 dBc, and the phase noise at 10 Hz offset will be -63 dBc instead of the required -70 dBc.

1.8 Project Description

The Mars Global Surveyor (MGS) mission will deliver a single spacecraft to Mars for an extended orbital study of the planet's surface, atmosphere, and gravitational and magnetic fields. This spacecraft will weigh no more than 1,060 kilograms fully loaded at the time of launch. The current target mass is about 1,052 kilograms.

Launch will occur during the November 1996 Mars opportunity by a Delta 2/7925 launch vehicle, with a flight time of just over 10 months. During the cruise period, a series of small trajectory correction maneuvers (TCMs) will be performed to remove planetary protection injection biasing of the upper stage, to correct trajectory dispersions introduced by the upper stage during injection, and to control the approach trajectory to Mars for planetary protection purposes.

Upon arrival at Mars in September 1997, the spacecraft will be inserted into an initial highly elliptic capture orbit with a nominal period of 48 hours. Over the next few months, the spacecraft will be gradually lowered to the desired mapping orbit by a series by aerobraking maneuvers. Transition into the mapping orbit is expected by March 1998.

Upon achieving mapping orbit, repetitive observations of the planet's surface and atmosphere will be conducted for one Martian year, about 687 days. After the mapping phase ends, the spacecraft will support the International Mars Exploration Program by relaying data from various landers and atmospheric vehicles for a three year period.

1.8.1 Key Mission Events

Event	Date	Comments
Launch	5-Nov-1996	Launch period opens on 5-Nov-1996 and closes on 25-Nov-1996
Inner Cruise Phase	5-Nov-1996 to 6-Jan-1997	Communications through LGA only because solar arrays must be pointed at a fixed angle to Sun
TCM1	20-Nov-1996 (L+ 15 days)	Trajectory correct for injection errors
Outer Cruise Phase	6-Jan-1997 to 11-Sep-1997	Communications through HGA, phase begins when Earth-MGS-Sun angle falls below 60 degrees
TCM2	20-Mar-1997 (TCM1+ 120 days)	Correct for execution errors from TCM1
TCM3	19-Apr-1997 (TCM2+ 30 days)	Correct for execution errors from TCM2
TCM4	22-Aug-1997 (MOI- 20 days)	Final adjustment to MOI aim point
Mars Orbit Insertion (MOI)	11-Sep-1997	MOI can vary from 11-Sep-97 to 22-Sep-97 depending on exact launch date
Orbit Insertion Phase	11-Sep-1997 to 15-Mar-1998	begins at MOI, lasts 5 months to reach mapping orbit using aerobraking and propulsive maneuvers
Mapping Phase	15-Mar-1998 to 31-Jan-2000	Mars mapping operations for one Martian year, about 687 days
Relay Phase	31-Jan-2000 to 1-Jan-2003	About 3 Earth years

The TCM dates reflect a 5 November 1996 launch and are subject to change as the navigation team optimizes the interplanetary ΔV.

1.8.2 Experiments Description

Mission Objectives

Complete as fully as possible, a selected subset of the original science objectives of Mars Observer as follows:

a) Characterize surface morphology at high spatial resolution to quantify surface characteristics and geological processes.

b) Determine the composition, map the distribution, and measure the surface thermophysical properties of surface minerals, rocks, and ices.

c) Determine globally the topography, geodetic figure, and gravitational field.

d) Establish the nature of the magnetic field and map the crustal remnant field.

e) Monitor global weather and thermal structure of the atmosphere.

f) Study surface-atmosphere interaction by monitoring surface features, polar caps, polar thermal balance, atmospheric dust, and clouds over a seasonal cycle.

Provide multiple years of on-orbit relay communications capability for Mars landers and atmospheric vehicles from any nation interested in participating in the International Mars Surveyor Program.

Support planning for future Mars missions through data acquisitions with special emphasis on those measurements which could impact landing site selection.

Scientific Instruments

Instruments to be used in support of the science objectives and the associated home institutions of the principal investigators are:

Acronym	Full Name	Lead Center
MAG / ER	Magnetometer / Electron Reflectometer	Goddard Space Flight Center (GSFC)
MOC	Mars Orbiter Camera	Malin Space Science Systems (MSSS)
MOLA	Mars Orbiter Laser Altimeter	Goddard Space Flight Center (GSFC)
TES	Thermal Emissions Spectrometer	Arizona State University
USO	Ultra Stable Oscillator for Radio Science	Stanford University (team leader)

1.8.3 Mission Operations Support

The following table provides a profile of the tracking support required by the project:

Time Period	Antenna	Tracking Coverage Required	Data Types
Launch to L+ 30 days (includes TCM1 at L+ 15 days)	34m HEF	Continuous	2-way coherent Doppler and ranging, angular data from launch to L+ 1 day, acquire tracking data as soon as possible after launch
L+ 30 days to MOI- 90 days (except for TCM2, TCM3)	34m HEF	10 hours/pass 1 pass/day	2-way coherent Doppler, 3-way Doppler, and ranging
TCM2 (TCM1+ 120 days) TCM3 (TCM2+ 30 days)	34m HEF	Continuous for a period of 3 days before TCM to 3 days after TCM	2-way coherent Doppler and ranging
MOI- 90 days to MOI- 30 days	34m HEF	10 hours/pass 2 pass/day	2-way coherent Doppler and ranging
MOI- 30 days to start of mapping (includes TCM4 at MOI- 20 days)	34m HEF	Continuous	2-way coherent Doppler, 3-way Doppler, and ranging
MOI- 24 hours to MOI+ 24 hours	70m	Continuous	1-way Doppler and ranging
Routine Mapping Operations (about 15-Mar-98 to 31-Jan-00) (see notes after this table)	34m HEF	10 hours/pass 1 pass/day plus 1 additional pass approximately every 3rd day for real time data	2-way coherent Doppler, 3-way Doppler, ranging, and open loop recording during atmospheric occultations

Time Period	Antenna	Tracking Coverage Required	Data Types
Science Campaigns A: 15-Mar-98 to 13-Apr-98 B: 29-Jun-98 to 6-Jul-98 C: 26-Oct-98 to 2-Nov-98 D1: 5-Jan-99 to 12-Jan-99 D2: 20-Jan-99 to 27-Jan-99 D3: 3-Feb-99 to 10-Feb-99 D4: 18-Feb-99 to 25-Feb-99 E: 3-May-99 to 10-May-99 F: 27-Sep-99 to 4-Oct-99 G: 13-Dec-99 to 20-Dec-99 (see notes after this table)	34m HEF	Continuous for 88 orbits (approximately 7.2 days)	Same as during routine mapping
Diametric Occultations Edge-on Orbital Configuration (28 day duration centered on dates of 28-Oct-98, 19-Feb-99)	34m HEF	10 hour/pass 2 pass/day (w/ 2 hour overlap) 28-Oct-98 and 19-Feb-99 require continuous coverage	During the overlap period, simultaneous 2-way coherent Doppler and 3-way Doppler. Otherwise, same as during routine mapping operations
Communications Relay Phase (22-Feb-00 to 1-Jan-03)	34m HEF	10 hours/pass 1 pass/day	2-way coherent Doppler and ranging

All passes will have telemetry and command

The TCM dates listed in the table above reflect a launch on 5 November 1996. The actual dates vary with the launch date, and may change within the next half year as the navigation team optimizes the interplanetary ΔV.

Stations other than a 34m HEF, such as a 34m BWG or 70m, may only be substituted with negotiation from the project. The 34m BWG must have open loop and closed loop radio science capabilities that meet the radio science requirements between October 1997 and December 2003.

DSN Response:

The DSN accepts the MGS coverage requirements for mission support as defined in the table above. The DSN will comply within DSN scheduling guidelines, subject to the resource allocation process and the 34 BWG antenna limitation defined in Section 1.7.

1.9 Launch Vehicle Description

The MGS spacecraft will be launched from the Cape Canaveral Air Station (CCAS) Launch Complex 17 by a Delta 2/7925 rocket with a 9.5 foot diameter payload fairing. This booster employs nine small, solid propellant motors that strap onto the first stage, liquid propelled first and second stages, and a spin stabilized, solid propelled third stage. Stage one employs a propellant mix of RP-1 and liquid oxygen, while stage two uses a hypergolic mix of Aerozine 50 and nitrogen tetroxide. The first two stages of the Delta rocket will inject the third stage and the MGS spacecraft into a circular, low Earth parking orbit at an altitude of 185 kilometers. Stage two performs a second burn roughly half an hour after parking orbit insertion to begin the trans-Mars injection process. Stage three completes the trans-Mars injection burn.

1.10 Injection Vehicle Description

The third stage of the Delta 2 consists of a solid-propelled, spin-stabilized rocket. Essentially, the third stage is a Thiokol STAR-48B motor. Between 40 and 50 minutes after lift-off, the third stage will perform an 87 second burn to place the MGS spacecraft on an Earth escape trajectory. Spacecraft separation from the third stage will occur approximately 370 seconds after third stage ignition.

1.11 Spacecraft Description

The MGS spacecraft is a derivative of the Mars Observer spacecraft and consists of ten subsystems, nine hardware and one software. These subsystems are:

a) Attitude and Articulation Control Subsystem (AACS)

b) Electrical Power Supply (EPS)

c) Propulsion Subsystem (PRS)

d) Structure Subsystem

e) Thermal Control Subsystem (TCS)

f) Harness Subsystem

g) Mechanisms Subsystem

h) Command and Data Handling Subsystem (CDHS)

i) Telecommunications Subsystem

All together, the maximum spacecraft mass at the time of launch will be no more than 1,060 kilograms. The spacecraft dry mass accounts for approximately 666 of the total. At this time, the target total mass is about 1,052 kilograms.

1.11.1 Telecommunications Subsystem Specifics

The MGS spacecraft carries two X-Band radio transponders which are compatible with the DSN telecommunications design given in the DSN/Flight Project Interface Design Handbook (DSN 810-5). Each transponder drives a high power amplifier to provide redundant downlinks via a high gain or a low-gain antenna. Each transponder is connected to a low-gain receive antenna to provide separate uplink command channels. The input of one of the transponders is coupled via a diplexer to the high-gain antenna. An ultra-stable oscillator may be used to drive either of the transponders to provide a frequency stable downlink for radio science purposes. Key telecommunication parameters for MGS are listed in the next table.

Parameter	Value
Low Gain Antenna	
Gain	7.5 dBic (transmit / receive)
G/T	-28.2 dB/K (boresight)
EIRP	49.0 dBm (downlink)
High Gain Antenna	
Gain	38.6 dBic (transmit), 35.0 dBic (receive)
G/T	-17.28 dB/K (boresight)
EIRP	81.42 dBm (downlink)
Carrier Tracking Threshold	less than -154.7 dBm at MOT input (in 18 Hz loop bandwidth)
Frequency Acquisition and Tracking Rate	greater than 550 Hz/sec for -90 dBm at MOT input
Frequency Tracking Range	greater than ± 250 kHz for -90 dBm or greater
Frequency Capture Range	greater than ± 1.3 kHz for -90 dBm or above
Best Lock Frequency Stability	less than ± 20 ppm
MOT Noise Figure	less than 4.7 dB maximum
MOT Output Power	+12.0 dBm
TWTA Output	+44.2 dBm

1.12 Frequency Utilization Summary

The following frequencies have been assigned for MGS use:

Direction	Channel	Frequency
Uplink	16	7164.624299 MHz
Downlink	16	8417.716050 MHz
Downlink	20	8423.148147 MHz

At any one time, there are two downlink frequencies. If the X-band channel at 8417.716 MHz is selected, then the spacecraft will also be able to downlink at 31987.329 MHz (Ka-band). A second X-band channel at 8423.148 MHz also exists. If that one is selected, then the spacecraft will also be able to downlink at 32007.962 MHz (Ka-band). The Ka-band downlink is a TMOD engineering demonstration only.

1.13 Injection Vehicle Metric Tracking System

The Delta 2 third stage will carry a 2.2525 GHz tracking beacon. Downlink from this beacon will be left on until battery depletion for the purpose of assisting the DSN in the spacecraft initial acquisition process.

1.14 Spacecraft Telemetry Parameters

The MGS spacecraft telemetry parameters are given fully in the MGS/DSN Telecommunications Design Control Document. Some of those parameters of interest to the DSN are summarized below:

Parameter	Value
Modulation Index	42.5 to 80.0 degrees (selectable)
Modulation Type	PCM (NRZ-L) / PSK / PM
Sub-Carrier (square wave)	320 kHz 21.333 kHz (10 bps and 250 bps only)
Coding	Convolutional R = 1/2, K = 7 Reed Solomon
Engineering Data Rates	10, 250, 2000, 8000, 32000 (bps)
Science Data Rates (Realtime)	4000, 8000, 16000, 32000, 40000, 64000, 80000 (sps)
Science Data Rates (Recorded Playback)	21333, 42666, 85333 (sps)
Format	CCSDS Packet Telemetry

In the table above, “sps” stands for “symbols per second.” A symbol is essentially a Reed-Solomon encoded (250:218 ratio) data bit. Therefore, it takes approximately 1.147 bits of storage space to encode one bit of raw data. This amount does not include Viterbi encoding.

1.15 Spacecraft Command Parameters

The MGS spacecraft command parameters are fully listed in the MGS/DSN Telecommunications Design Control Document. Some of those parameters of interest to the DSN are summarized below:

Parameter	Value
Modulation Index	51.6 to 74.5 degrees (selectable)
Modulation	PCM / PSK / PM
Subcarrier (sine wave)	16 kHz
Bit Rates	7.8125, 15.625, 31.25, 62.5, 125, 250, 500
Format	DSN CMD 4-6

1.16 Spacecraft Radio Metric Parameters

Two coherent phase-lock turnaround transponders on the MGS spacecraft provide for the generation of two-way coherent Doppler data from the spacecraft X-Band uplink and downlink carrier frequencies. In addition, an ultra-stable oscillator (USO) is available to provide a highly stable and predictable downlink for one-way Doppler operation during radio science occultation experiments. The spacecraft transponders also have the capability to re-transmit the DSN sequential ranging waveform for generating of ranging data when required.

There is no project requirement for generating the delta-DOR type of interferometry data during the mission.

The MGS spacecraft radio metric parameters are fully listed in the MGS/DSN Telecommunications Design Control Document. Some of those parameters of interest to the DSN are summarized below:

Parameter	Value
Total Range Delay	About 700 ns
Change in Range Delay Over Flight Temperature Range	40 ns over -28°C to +75°C 6 μs over any 10°C range
Downlink Modulation Index	0.29 peak rad
Uplink Modulation Index	0.78 to 1.2 peak rad
Carrier Phase Delay	1.3 μs over -28°C to +75°C 0.01 μs/°C slope

1.17 Launch Vehicle Sequence of Events

Currently, there are two launch opportunities each day (either a 93° or 98° flight azimuth boost trajectory) from 5 November 1996 to 15 November 1996. This dual azimuth strategy will give the Delta two opportunities per day to launch. After 16 November, the launch azimuth will switch to 110° for the remainder of the launch period. This switch is necessary because starting on the 16th of November, the declination of the departure asymptote will exceed the latitude of the launch site.

The launch vehicle flight sequence of events are summarized in the next table. In general, the actual trans-Mars injection times vary across the launch period depending on the geometry of the outbound hyperbolic asymptote.

Event	Mission Elapsed Time (11/5 to 11/15)	Mission Elapsed Time (11/16 to 11/24)
Lift-Off	0 .000 seconds	0.000 seconds
Mach 1	32.258	32.258
Maximum Dynamic Pressure	49.458	49.458
Solid Rocket Motor Jettison (6 of 9)	67.000	67.000
Solid Rocket Motor Jettison (3 of 9)	131.500	131.500
Stage 1 Main Engine Cut-Off	260.664	260.664
Stage 1 Jettison	268.664	268.664
Stage 2 Ignition	274.164	274.164
Jettison Payload Fairing	282.000	289.000

Event	Mission Elapsed Time (11/5 to 11/15)	Mission Elapsed Time (11/16 to 11/24)
Stage 2 First Cut-Off	575.010	580.832
Stage 2 Restart	Stage 2 cut-off, minus ~120 seconds	Stage 2 cut-off, minus ~120 seconds
Stage 2 Second Cut-Off	Stage 3 ignition, minus 90.000 seconds	Stage 3 ignition, minus 90.000 seconds
Stage 2 Jettison	Stage 3 ignition, minus 37.000 seconds	Stage 3 ignition, minus 37.000 seconds
Stage 3 Ignition	Stage 3 burn-out, minus 87.14 seconds	Stage 3 burn-out, minus 87.14 seconds
Stage 3 Burn-Out	44 to 50 minutes after lift-off	39 to 47 minutes after lift-off
Yo-yo deploy and Despin	369 seconds after Stage 3 ignition	369 seconds after Stage 3 ignition
Spacecraft Separation from Stage 3	370 seconds after Stage 3 ignition	370 seconds after Stage 3 ignition

The exact lift-off and trans-Mars injection times have not yet been determined. Current estimates show that for the first half of the launch period, lift-off will vary from as late as 18:13 UTC (November 5th) to as early as 14:37 UTC (November 15th). For the second half of the launch period, lift-off will occur as late as 18:40 UTC (November 16th) to as early as 15:21 UTC (November 25th). More detailed information can be found in Reference 9.

1.17.1 Launch Vehicle Trajectory Data

The current baseline ascent trajectory utilizes the short-coast launch opportunity. This option involves insertion into a near-circular parking orbit above the Atlantic Ocean, and trans-Mars injection over the eastern Indian or western Pacific Ocean. In this case, DSN initial acquisition will occur over Canberra. More detailed trajectory information can be found in Reference 9.

1.17.2 Spacecraft Injection Parameters

MGS spacecraft injection parameters will be provided by MGS to the JPL DSN Multi-mission Navigation Control Center, and to the project navigation team in the form of inter-center vectors (ICV's).

2. Radio Frequency Telecommunications Requirements

2.1 Telecommunications Link Performance Summary

Telecommunications link performance summaries for significant segments of the MGS mission are given in MGS/DSN Telecommunications Design Control Document. The performance data in that document is based on the DSN telecommunications performance specifications specified in MGS Mission Operations Specifications Document and the spacecraft parameters summarized in Section 1.11.1 of this document.

The project plans to utilize three basic rates for the return of recorded data (either 21. 3 ksps, 42.7 ksps, or 85.3 ksps) and will select the highest rate supportable by the link. As specified in the MGS Mission Plan, the spacecraft will return recorded data at 21.3 ksps from 15 March 1998 to 21 September 1998, at 42.7 ksps from 22 September 1998 to 28 December 1998, at 85.3 ksps from 29 December 1998 to 8 November 1999, and at 42.7 ksps from 9 November 1999 to the end of the mapping phase on 31 January 2000.

Return of realtime data every third day and during the science campaigns will normally occur at the 40.0 ksps realtime rate. However, when the link margin allows, the project may chose to implement the 80.0 ksps realtime rate on a "best-effort" basis. See Section 6.4.2 of the MGS Mission Plan for more information.

DSN Response:

The DSN concurs with the telecommunications link design given the assumptions stated above.

2.2 Deep Space Network Requirements Summary

The DSN is required to support the MGS Mission on the 34m HEF and 70m antennas with the capacity and performance capabilities described in this document consistent with the assumptions made in Section 2.1. Specifically, the DSN shall:

a) Acquire all downlinks (with data rates higher than 16.8 ksps) designated for the pass within five minutes of spacecraft view on the first acquisition, and within one minute on any subsequent pass reacquisition. Data rates of 4 ksps will also nominally require one minute for subsequent pass reacquisition.

b) Ensure global coverage of the MGS scientific data capture function by providing the DSN station coverage identified in and subject to the constraints given in Section 1.8.3.

c) Provide all X-Band downlink telemetry in the range 10 bps to 85.3 ksps in the form of transfer frames that are synchronized, Viterbi decoded, and SFDU formatted.

d) Provide X-band uplink command capability at 7.8 to 500 bps with a nominal rate of 125 bps.

e) Provide all data to AMMOS within 12 hours.

f) Retain all data, except for monitor data, for 30 days with recall capability.

g) Provide radio metric data and calibration in the form of two-way coherent Doppler and ranging data to MGS navigation (on the OSCAR node) and SFDU formatted data files delivered to the project data base.

h) Provide in near-real-time X-Band open loop radio science data for Mars occultations during the mapping phase in SFDU format data files.

i) Transmit DSN Monitor data (MON 5-15) to AMMOS in SFDU format.

j) Provide data and voice communications for project support that includes voice circuits and 9.6 kbps, 56 kbps, 224 kbps and 448 kbps data circuits to the launch site, external scientific investigators, and the spacecraft manufacturer (Lockheed-Martin, in Denver, CO). External circuits are to be forecasted, budgeted, ordered, and maintained by NASCOM.

DSN Response:

The DSN will comply with the requirements listed above.

2.2.1 Project Navigation Radio Metric Requirements

Data Accuracy and Calibration

The acquisition and data conditioning process shall be designed such that the data accuracy requirements are maintained and there is a high probability that all data processed are valid.

The contribution of the DSN to the tracking data error, due to station hardware or instrumental effects and radio signal propagation through the Earth's atmosphere and interplanetary medium, are specified in the following table:

Radio Metric Data Type	Required Accuracy (3σ)
Two-way coherent Doppler (60 seconds)	0.54 mm/sec
Round trip travel time or range	13.4 meters
Difference Doppler (60 seconds) (simultaneous two-way coherent and three-way Doppler)	0.16 mm/sec

The following calibrations are required for the radio metric data:

a) Doppler corrections or calibrations for the Earth’s troposphere and ionosphere.

b) Timing and polar motion polynomials compatible with the Orbit Determination Program (ODP) software.

c) Range data calibrations for atmospheric effects, ground instrument effects, and spacecraft time delay.

Station Coordinates and Accuracy

The accuracy of the cylindrical coordinates of all tracking stations used to acquire radio metric data are given in the following table:

Coordinate	Absolute Accuracy (3σ)	Relative Accuracy (3σ)
Longitude	0.69 meters	0.30 meters
Distance from spin axis	0.54 meters	0.30 meters
Distance perpendicular to Earth equatorial plane	0.70 meters	0.30 meters

Coordinate system is Earth Rotational Service Standard

A complete set of station coordinates and an error covariance matrix shall be provided to the MGS navigation team consistent with the planetary ephemeris used for flight operations.

Data Conditioning and Delivery

The DSN shall provide a minimum of 95% of all available radio metric data during scheduled DSN passes. Raw navigation data shall be provided in the form of an archival tracking data file (ATDF). The raw navigation data shall also be conditioned (data sampling, elimination of erroneous data, and application of calibrations) and provided in the form of an archival tracking data file (ATDF) and orbit data file (ODF). The ATDF and ODF shall be provided in standard formatted data unit (SFDU) format to the AMMOS for transfer to the MGS PDB. The ODF file shall also be provided directly to the project navigation team on OSCAR.

a) Interplanetary Phase

Nominally, edited ODF files shall be provided to the MGS navigation team twice per week during the interplanetary phase, except as follows:

1) During periods of intense navigation activity, such as injection, TCMs, and the MOI maneuver, ODF files are generally required within one hour of the end of the tracking pass. Partial data files may be required during a tracking pass.

2) Special conditions apply during the launch phase. During the first several tracking passes, radio metric data deliveries are required every hour.

b) Orbit Insertion Phase

Orbit insertion phase lasts from the MOI maneuver to beginning of mapping and includes aerobraking. The nominal delivery frequency of edited ODF files varies as follows:

1) One delivery per day, including weekends and holidays, is required from MOI to the point in aerobraking when the spacecraft orbit has decayed to a 24 hour period. This time period covers the walk-in maneuvers that are tentatively scheduled to occur at MOI+ 9 days, MOI+ 17 days, MOI+ 23 days, and MOI+ 31 days.

2) Two deliveries per day, including weekends and holidays, are required when the spacecraft's orbit has decayed to less than 24 hours, but is still greater than 12 hours.

3) Four deliveries per day, including weekends and holidays, are required from the time beginning when the spacecraft's orbit has decayed to 12 hours until the end of aerobraking. This time span includes the walk-out phase that raises the periapsis out of the Martian atmosphere.

4) Two deliveries per day, including weekends and holidays, are required from the end of walk-out to the beginning of mapping. This time span includes the transition to mapping orbit, and gravity calibration activities prior to the start of mapping.

5) Requirements one through four are superseded by this requirement when propulsive maneuvers occur. During these times, the navigation team requires delivery within one hour after the end of the maneuver, and may request several deliveries at one hour intervals after the maneuver.

c) Mapping Phase

During the nominal mapping phase, edited ODF files are required 12 hours after the end of a tracking pass (excluding weekends and holidays). If this time should occur outside normal working hours (0800 to 1700 local time Monday through Friday), then that data shall be available to the navigation team by 0800 of the next working day, except as follows:

1) Radio metric data is required within one hour of the end of the pass whenever a propulsive maneuver occurs within the pass.

<u>DSN Response</u> :

The DSN will comply with requirements listed above.

2.2.2 Radio Science Requirements

Radio science experiments carried out on MGS will advance the two fields of interest fundamental to the study of Mars. First, radio occultation observations of the polar atmosphere will provide consistent and accurate long term monitoring of the total gas content and vertical structure of the neutral atmosphere. Second, radio Doppler tracking of the spacecraft will provide improved information on the structure of the Martian gravitational field through measurements of its effect on the spacecraft's motion. Unlike any other MGS experiment team, the radio science team will not rely on a "scientific instrument." Instead, they will use the telecommunications subsystem, augmented by an ultra-stable oscillator, operating together with one of the several ground tracking stations of the DSN.

Closed-Loop Tracking Data Requirements for Radio Science

a) The DSN shall measure downlink carrier Doppler in either a non-coherent mode or two-way coherent mode. The 3σ contribution to two-way coherent Doppler range rate error from DSN equipment shall be less than 0.1 mm/s for a 10 second integration.

b) The DSN shall measure the range between the spacecraft and the tracking station. The 3σ contribution to range measurement noise from DSN equipment shall be less than 3 meters.

c) The DSN station locations shall be provided with at least the following accuracy:

Parameter	Absolute Accuracy (3σ)
Distance from Earth's spin axis	1.0 meters
Longitude	1.5 meters
Distance from Earth's equatorial plane	10 meters

Accuracy of DSN station coordinates relative to other DSN stations shall be within 30 cm. In addition, a complete error covariance matrix shall be provided.

d) The DSN shall provide timing and polar motion files containing the best estimates of the past and future Earth rotation and polar motion.

e) The DSN shall provide calibrations for the terrestrial ionosphere and troposphere to the Doppler and range measurements.

f) The DSN shall generate Doppler and range predictions and compute residuals from actual measurements. Residuals shall be delivered within the monitor data blocks and be available for AMMOS processing within one minute of their generation.

g) The DSN shall provide measurements of the weather at each DSCC during MGS track. The data shall include, at a minimum, near surface temperature, barometric pressure, and dew point.

h) Tracking and ancillary data shall be provided in the following files and data streams. They are described in JPL Document 820-13. The tracking files shall be delivered on the schedule provided by the MGS navigation team.

1) Archival Tracking Data Files (820-13, TRK 2-25)

2) Orbit Data Files (820-13, TRK 2-18)

3) Media Calibration Data Files (820-13, TRK 2-23)

4) Earth Orientation Parameter Files (820-13, TRK 2-21)

5) DSN Monitor Data (820-13, MON 5-15)

6) Meteorological Data Files (820-13, TRK 2-24)

Open-Loop Tracking Data Requirements for Radio Science

a) The DSN shall acquire radio science open-loop data and deliver electronically to AMMOS the radio science original data stream (ODS) in DSN format 820-13 RSC-11-11B. The DSN equipment involved in the acquisition and delivery of radio science data shall be reliable enough to deliver the ODS, gap free and with a bit error rate of less than 1×10^{-7}, from 95% of all occultations that occur during regularly scheduled tracking passes. The delivered ODS from each tracking pass shall be available on the PDB nominally within two hours of the end of that tracking pass.

b) The DSN shall provide a spectral display of the recording bandwidth and status, configuration, and performance data as described in 820-13 RSC-11-12 for monitoring the progress of open-loop data acquisition. The data shall be available for AMMOS processing within five minutes of its generation.

c) The DSN will produce tuning and event predicts for operation of the radio science subsystem’s open-loop receivers and DSP-R. A copy of the predicts shall be delivered to the radio science support team at JPL and the radio science team at Stanford University at least two working days prior to the applicable tracking pass. Furthermore, the project will assume responsibility for all radio science predicts once remote operations of the open loop radio science system becomes operational.

d) The tuning of the open-loop receivers shall remain within 10 Hz (at X-band) of predicts at all times.

e) The DSN shall provide the capability to record open-loop data digitally using 12 bit samples.

f) The data record shall include time tags with an absolute accuracy of better than 100 µs.

g) During occultation measurements, pointing of the DSN antennas shall be sufficiently accurate and stable to limit any resulting 3σ variations in the received signal intensity to less than 0.1 dB over any 20 second interval.

h) The overall 3σ amplitude stability of the DSN equipment involved in open-loop recording shall be better than 0.1 dB over any five minute period. This constraint does not include antenna pointing, spacecraft effects, and transmission media effects.

i) The DSN equipment involved in radio science open-loop recording shall meet the following requirements for frequency stability (expressed in terms of the Allan deviation) listed in the next table.

Integration Time (seconds)	DSN Requirement	DSN Goal
1	6.6×10^{-13}	9.3×10^{-14}
10	2.6×10^{-13}	3.9×10^{-14}
100	2.6×10^{-13}	4.4×10^{-14}
1000	2.6×10^{-13}	6.6×10^{-14}

These requirements and goals are derived from the characteristics of the spacecraft USO, listed in the next table. Specifically, the DSN requirements ensure that the DSN equipment will not degrade the frequency stability of a signal whose Allan deviation matches the design requirements of the USO by more than 20%. The DSN goals are derived in the same way from the measured USO performance, which exceeds its requirements. Performance at the level of these goals will enhance the value of the radio occultation experiments.

Integration Time (seconds)	USO Requirement	USO Test Results
1	1.0×10^{-12}	1.4×10^{-13}
10	4.0×10^{-13}	5.9×10^{-14}
100	4.0×10^{-13}	6.6×10^{-14}
1000	4.0×10^{-13}	1.0×10^{-13}

j) The DSN equipment involved in radio science open-loop recording shall meet the following requirements for phase noise (dbc in 1 Hz, SSB, X-band):

Frequency Offset (Hz)	DSN Requirement	DSN Goal
1	-53	-60
10	-70	-70
100	-70	-70
1000	-70	-70

As in the previous item, these requirements and goals are derived from the characteristics of the spacecraft USO listed in the next table. However, the DSN requirements and goals at some frequency offsets have been relaxed to reflect the expected SNR limitations of the MGS radio occultation experiments.

Frequency Offset (Hz)	USO Requirement	USO Test Results
1	-49	-56
10	-74	-77
100	-83	-83
1000	-84	-84

k) Modulation sidebands or spurious signals caused by DSN equipment involved in open-loop recording shall be no greater than -70 dBc within 500 Hz of the carrier and no greater than -60 dBc at 500 to 2000 Hz from the carrier.

l) Recording bandwidths from 100 Hz to 20 kHz shall be available.

m) The DSN will implement a radio science workstation at each of the complexes to allow remote configuration and operation of the radio science system.

Items i, j, and k listed for open-loop recording requirements are end-to-end requirements and include the effects of all DSN radio science system components. Among these are effects due to subreflector motion, linearity of analog to digital converters, uniformity of the sampling interval, and the accuracy of the reported POCA frequency.

DSN Response :

The DSN will comply with the closed loop radio science requirements. The DSN will comply with the open loop radio science requirements specified in items “a” through “i” and “k” through “m,” but cannot meet the phase noise requirements as specified in item “j.” The phase noise at 1 Hz offset will be -52 dBc instead of the specified -53 dBc, and the phase noise at 10 Hz offset will be -63 dBc instead of the required -70 dBc.

2.2.3 Telemetry (Downlink) Requirements:

Data Rate and Delivery Time

The DSN is required to support X-Band telemetry at data rates of 10 bps to 32 kbps and at Reed-Solomon encoded rates of 4 ksps to 85.3 ksps in accordance with the parameters of Section 1.14 of the DMR.

Telemetry data shall be provided to the AMMOS in the form of convolutionally decoded, "transfer-frame" synchronized, real-time data streams in SFDU format as described in DSN 820-13 TLM 3-20. For spacecraft engineering purposes, engineering transfer frames should be delivered to AMMOS within five minutes of capture by the DSN. The DSN shall also ensure that all committed telemetry data are provided to the AMMOS within 12 hours of receipt by the DSCC, and that 99.5% of successfully received data is not permanently lost due to a ground communications failure. The DSN shall maintain a data recall capability for 30 days. The DSN shall have the capability of Reed-Solomon decoding the data at the DSCC.

During periods of safe mode operations, the DSN shall provide a 70m antenna for downlink telemetry when the 10 bps downlink cannot be provided by the 34m antenna.

Telemetry Data Acquisition Time

During cruise, orbit insertion, and mapping phases, the viewing station must be able to acquire the X-band downlink and achieve telemetry "in-lock" within five minutes of predicted telemetry signal reception at the tracking station for data rates of 18.6 ksps or greater. During the mapping phase, reacquisition of the telemetry signal following each Earth occultation shall be achieved within 60 seconds of arrival of the signal.

Data Return

The DSN shall capture and transfer to MGSO 95% of the available science data transmitted by the spacecraft with sufficient link margin during the mapping phase.

The 95% requirement refers to total data volume (quantity), and is intended to allow for DSN operational problems or temporary hardware failures (out of service). MGS also has a quality and continuity requirement, which applies to the 95% data which is delivered.

When science and engineering (S&E) telemetry is received by the DSN, with a bit SNR (E_b/N_o) at input to symbol-synchronization of at least 4 dB, TMOD shall provide quality, continuity, and latency for science packets delivered to the project database such that, within 12 hours of data capture, the delivered data contains no more than one packet gap or error within 10,000 packets, on average. The S&E telemetry stream is both Reed-Solomon and Convolutionally encoded. This requirement is driven by the fact that the Mars Orbiter Camera (MOC) instrument makes extensive use of data compression, and cannot tolerate significant corruption or gaps in the packets returned. A MOC packet is about 10,000 bits in length.

In addition to meeting the above requirements, TMOD shall provide appropriate operations data accountability tools to measure performance and diagnose problems in telemetry quality and continuity.

DSN Response :

TMOD will meet the specified telemetry requirements for MGS. TMOD will design and implement an end-to-end telemetry delivery system to meet the MGS one in 10,000 packet error tolerance requirement. The final MGS configuration will be provided by June 1997. In addition, the backup mode using the Central Data Recorder will be operational in May 1996.

2.2.4 Command (Uplink) Requirements:

The DSN shall provide X-band command capability during a minimum of 95% of all supporting pass time at a rate of 7.8128 bps to 500 bps on all scheduled MGS support periods . The nominal rate shall be 125 bps, but higher rates may be used if command link performance margins allow. During commanding, the DSN format that will be used is 820-13 CMD 4-6.

Emergency commanding capability at 7.8125 bps at maximum Mars communications range with adverse spacecraft low gain antenna orientation is required from at least one 34m HEF station.

DSN Response :

The DSN will comply with the requirements for command support. With respect to the requirement for emergency commanding, it is assumed that the command link margins will be the same or better than those for Mars Observer.

2.2.5 Monitor Requirements

The DSN shall provide monitor data (MON 5-15) in SFDU format, in real time, to AMMOS during all scheduled MGS support periods, including pre-launch activities.

DSN Response:

The DSN will comply with the monitor requirements.

2.3 Interagency Networks Requirements Summary

This section is not applicable to the Mars Global Surveyor project.

2.4 International Networks Requirements Summary

This section is not applicable to the Mars Global Surveyor project.

3. Testing and Training Requirements

3.1 Pre-launch Compatibility Testing

In the pre-launch period, the project will require the services of the Compatibility Test Trailer for interfacing with the spacecraft for DSN compatibility testing, and DTF-21 for GDS and MOS test and training. During pre-launch operations at the Cape Canaveral Air Force Station and the Kennedy Space Center, the project will require the support of MIL-71 for interfacing with the spacecraft in support of final DSN spacecraft compatibility tests and MOS end-to-end tests. The specific dates and support requirements will be provided at least one year prior to the earliest need date.

A compatibility test plan has been written by the project with inputs from TMOD. Compatibility test procedures (project for the spacecraft portion, and DSN for the DSN equipment portion) will be written. The DSN will conduct the compatibility tests. A joint, final test report containing the test results and the conclusion will be compiled.

3.2 MOS Test and Training

Project MOS test and training functions to be conducted prior to launch shall require the participation of all the DSN facilities committed to support launch and cruise operations. MOS test and training functions to be conducted after launch will require the participation of all the DSN facilities committed to support encounter flight operations.

3.3 Simulation Requirements

In association with the facility support described above, the DSN shall generate simulated telemetry data streams at all the data rates in accordance with the table in Section 1.14. In addition, the DSN shall support a project/MGSO file transfer protocol (FTP) interface to the telemetry simulation assembly (TSA) for project simulated data. These capabilities are required at all DSN facilities including DTF-21 and MIL-71, which will be supporting the Project.

DSN Response :

The DSN will comply with the requirements in Sections 3.1, 3.2, and 3.3.

4. Network Operations Control Center Requirements

4.1 General Support

The JPL Network Operations Control Center (NOCC) / Complex Link Controller shall carry out the following general operational support functions for the MGS mission:

a) Monitoring DSN performance in support of MGS

b) Alerting the project to abnormal or anomalous conditions

c) Providing an operational contact point for coordinating near real time changes in scheduling between the DSN and the project

d) Coordinating the delivery of all negotiated data products to the project via AMMOS or other agreed interfaces.

e) Serving as the DSN point of contact for performance and troubleshooting related queries.

DSN Response:

The DSN will comply with the NOCC requirements.

5. Ground Communications and Data Transport

5.1 General Ground Communications Requirements

The DSN shall provide data and voice communications between the AMMOS and DSN facilities committed to support the mission coverage requirements listed in section 1.8.3 of this document. During the pre-launch and launch period, the DSN shall provide communications circuits for data and voice transmission between the launch vehicle and JPL.

5.2 Special Ground Communications Requirements

During the pre-launch period, the DSN shall provide communications circuits for data and voice transmission between the contractor facility at Lockheed-Martin in Denver, CO and JPL to support spacecraft system test. Additional voice and data circuits will be required to support the Lockheed Martin spacecraft team support of the mission in Denver, CO.

The Project also requires special science data communications circuits between JPL AMMOS and each of the MGS Principal investigators, team leaders, and interdisciplinary Scientists. These voice and data circuits, plus the modem terminal equipment, are to be provided to the project by NASCOM.

5.3 Communications Circuits Active Lifetime

The end of the mapping phase is in January, 2000. However, all of the science circuits will remain operational until the end of the mission in January, 2003. The operational periods of the special science circuits are included in the following table:

User	Location	NASCOM Circuits Needed
Mars Orbiter Camera Mars Relay (MOC & MR)	Malin Space Science Systems San Diego, CA	1 Each, 9.6K FDX data (7-Jan-94 to 1-Jul-95) 1 Each, 224K FDX data (1-Jul-95 to 1-Jan-03) 1 Each, Voice Circuit (1-Oct-95 to 1-Jan-03)
Radio Science (USO)	Stanford University Palo Alto, CA	1 Each, 9.6K FDX data (7-Jan-94 to 1-Jul-95) 1 Each, 56K FDX data (1-Jul-95 to 1-Jan-03) 1 Each, Voice Circuit (1-Oct-95 to 1-Jan-03)
Thermal Emission Spectrometer (TES)	Arizona State University Tempe, AZ	1 Each, 224K FDX data (1-Jul-95 to 1-Jan-03) 1 Each, Voice Circuit (1-Oct-95 to 1-Jan-03)
Mars Orbiter Laser Altimeter (MOLA)	Goddard Space Flight Center Greenbelt, MD	1 Each, 56K FDX data (1-Jul-95 to 1-Jan-03) 1 Each, Voice Circuit (1-Oct-95 to 1-Jan-03)
Magnetometer (MAG)	Goddard Space Flight Center Greenbelt, MD	1 Each, 56K FDX data (1-Jul-95 to 1-Jan-03) 1 Each, Voice Circuit (1-Oct-95 to 1-Jan-03)
Industrial Partner (LMA)	Lockheed-Martin Denver, CO	1 Each, 56K FDX data (15-Oct-94 to 1-Apr-95) 1 Each, 448K FDX data (1-Apr-95 to 1-Jan-03) 1 Each, T1 for voice (1-Oct-95 to 1-Jan-03)
Interdisciplinary Scientist (IDS-STL)	Washington University St. Louis, MO	1 Each, 56K data (1-Feb-97 to 1-Jan-03)

User	Location	NASCOM Circuits Needed
Interdisciplinary Scientist (IDS-MP)	United States Geological Survey Menlo Park, CA	1 Each, 56K data (1-Feb-97 to 1-Jan-03)
Interdisciplinary Scientist (IDS-B)	University of Colorado Boulder, CO	1 Each, 56K data (1-Feb-97 to 1-Jan-03)
Interdisciplinary Scientist (IDS-MF)	Ames Research Center Moffit Field, CA	1 Each, 56K data (1-Feb-97 to 1-Jan-03)
Interdisciplinary Scientist (IDS-F)	United States Geological Survey Flagstaff, AZ	1 Each, 56K data (1-Feb-97 to 1-Jan-03)
Interdisciplinary Scientist (IDS-P)	California Institute of Technology Pasadena, CA	1 Each, 56K data (1-Feb-97 to 1-Jan-03)
Kennedy Space Center (KSC/CCAS)	Cape Canaveral Air Station and Kennedy Space Center, FL	1 Each, 224K FDX data (1-Jul-96 to 1-Dec-96) 3 Each, Voice Circuit (1-Jul-96 to 1-Dec-96)

All voice circuits must be compatible with the current digital VOCA system in use at JPL. The T1 requirement for Lockheed-Martin is to extend the digital voice capability at JPL to 24 instruments in the Remote Mission Support Area in Denver for operational support to the Lockheed-Martin provided spacecraft team, and to provide eight operational voice circuits throughout the mission for flight, and three circuits for launch operations. The MGSO system is currently, and may continue to be susceptible to propagation delays. Therefore, data circuits (to science sites and Lockheed-Martin) should not utilize satellite links. All of the above data circuits should have full duplex (FDX) capability and have at least the bandwidth specified. How this is implemented is up to the agency responsible for acting on this requirement.

In the event of a failure, the project requires that TMOD be capable of restoring end-to-end capability for the CCAS to JPL (launch phase only) and JPL to LMA data circuits within 30 minutes. End-to-end connectivity refers to functional network connectivity between end-user computing nodes. However, the MGS project requires that this 30-minute capability only be provided during key, critical mission events. Critical, as used in this section, is defined to include the period of final spacecraft check out at CCAS, launch, major scheduled propulsive maneuvers such as trajectory correction maneuvers and MOI, and the period during aerobraking between the time when the orbital period has decayed to six hours and the middle of the aerobrake walk-out (approximately 25 days).

During these critical mission phases, TMOD shall be capable of restoring the 2-way coherent Doppler data stream within 30 minutes (exclusive of round trip light time) of the data outage 95% of the time. In addition, the system shall be operated in a mode of “extreme heightened awareness” during the critical aerobraking period in an attempt to achieve the goal of restoring the 2-way coherent Doppler data stream within 15 minutes (exclusive of round trip light time) in the event of a data outage.

During the entire aerobrake phase of the mission and during critical mission phases as defined above, TMOD shall be capable of restoring telemetry and commanding services within two hours (including round trip light time) of service disruption 95% of the time. In the unlikely event that service is not restored within the allotted two hours, the project requires that TMOD restore commanding capability within 24 hours 99% of the time.

The two-hour restore requirement only applies to operations during the entire aerobraking phase and for critical events. During all non-critical, non-aerobraking phases of the mission, the time to restore telemetry and commanding services will be no greater than 12 hours 95% of the time.

The project requirement for “mean time between failure” (MTBF) for functions, including end-to-end data circuits, supporting tracking, telemetry, and commanding is no less than 500 hours (averaged over 30 days) for all mission phases. From the time when the orbital period has decayed to six hours until the end of aerobraking, the system shall be operated in a mode of “extreme heightened awareness” in an attempt to prevent no more than one two-hour failure from occurring (MTBF greater than 500 hours).

5.4 Communications Circuit Error Rate

The detected ground communications bit error rate for end-to-end data services between JPL and the DSN complexes (and other domestic communications segments) shall not exceed 1×10^{-7} over a 24-hour average period. Real-time data containing detected bit errors shall be discarded by the ground communications system, although this data shall be recorded for non-real-time retransmission and analysis if necessary. Additionally, the communications circuits shall perform error free for 99.5% of the time, as measured over a 24-hour average period.

DSN Response:

The DSN will comply with the communications requirements in Section 5.

6. Data Processing Requirements

6.1 General Requirements

The general project requirements on the DSN for processing, conditioning, and handling telemetry, radio metric, and radio science data are covered in the individual sections of this document.

The DSN shall provide Viterbi decoded data bits, including data, headers, PN code, and R-S parity in the same format as generated at the spacecraft prior to application of the convolutional codes. In addition, the DSN shall correct all corrupted bits (including the R-S parity bit) by applying the decoding functions (Viterbi,R-S) and/or redecoding at the SPC as a backup capability. This data shall be provided to the project consistent with the requirements stated in section 2.2.3.

DSN Response:

The DSN will comply with the data processing requirements in this section.

7. Trajectory Related Requirements

7.1 Trajectory Related Requirements

There are no trajectory related requirements on the DSN for the MGS mission.

7.2 Initial Acquisition Requirements

Following launch, the DSN Canberra Complex (CDSCC) shall acquire the spacecraft X-Band signal. This initial acquisition downlink and uplink shall occur within 30 minutes of the spacecraft turning on its RF transmitter and signal with significant link margin being available. The DSN shall be capable of performing this function out to an Earth to spacecraft range of 40,000 kilometers. The telemetry data rate at initial acquisition will be 10 bps or 2000 bps.

Canberra will be the prime station for DSN initial acquisition of the spacecraft. During days in the launch period when the departure trajectory allows a Goldstone view of the spacecraft, Goldstone will be used as a backup to Canberra.

7.3 Orbit Determination Requirements

The DSN multi-mission navigation team will compute the spacecraft trajectory during the first 10 hours after trans-Mars injection, will provide p-files for DSN predict generation, and will generate state vectors for the MGS navigation team.

DSN Response:

The DSN will comply with the requirements of this section.